RESEARCH CIRCULAR 123 SEPTEMBER 1963

Chemical and Physico-Chemical Characteristics of Rifle Peat Profiles

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CHEMICAL AND PHYSICO-CHEMICAL CHARACTERISTICS OF RIFLE PEAT PROFILES

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Abstract

Three distinct organic layers were observed in profiles of cultivated and virgin organic soil which previously had been classified as Rifle peat. The plow layer had properties characteristic of muck, the intermediate layer was composed of dark-brown, stratified fibrous material and the basal layer was sticky, structureless, black in color and probably contained gyttja or organic matter leached from surface layers and deposited on the mineral substratum.

Cation exchange capacity, DTA thermograms, electrophoretic mobility, calorific value, pyrophosphate solubility and carbon-nitrogen ratios indicated that most of the organic matter throughout the profiles could be classified as muck

The structure and composition of the soil througout the profile indicated that it can be used for crop production until the organic matter is lost by subsidence.

INTRODUCTION

Differences in the stratigraphy of organic soil profiles are caused by variation in type of initiation and development (2). Organic profiles may contain distinct layers of marl, gyttja, dy, diatomaceous earth, volcanic ash, pumice, fibrous peat and muck. The sequence of layers is dependent upon whether the formation process was progressive (wet to dry) or regressive (large and sudden changes in depth of bog water). Physical and chemical characteristics of the layers are usually not too well correlated (6). Such differences are of considerable importance when organic soils are drained and placed under cultivation. Roots may penetrate layers having differences in physical and chemical properties. Subsidence and wind erosion may expose and bring lower layers of the profile to the surface. Knowledge concerning the properties of organic profiles is of considerable value in determing the long time crop growing potential of such soils.

This study was conducted in order to obtain information on the chemical and physico-chemical characteristics throughout the profiles of a virgin organic soil and adjacent organic soils which had been under cultivation for 12 and 20 years.

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Materials and Methods

The profile samples were obtained from organic soil in the New Haven Marsh (1) on or near the Muck Crops Substation of the Ohio Agricultural Experiment Station near Celeryville, Ohio. The soil from which profile samples were taken has been classified as Rifle peat (8). Pits were dug to the depth of the water table in a soil which had been cultivated for 20 years (profile A), an adjacent soil (250 feet away) which had been cultivated for 12 years (profile B) and a virgin soil located about ½ mile from the cultivated soil. Samples were obtained at various depths from the profiles, placed in metal cans and frozen until analyzed.

Munsell color was determined for all samples in their natural and air-dried states. Carbon was determined by dry combustion; organic matter and ash were determined following dry combustion in a muffle furnace (12 hours at 500°C in a stream of oxygen), and nitrogen was determined by the Kjeldahl method using a catalyst containing HgO, $CuSO_4$ and Se. Soil reaction was determined with a glass electrode using a soil:water ratio of 1:15.

Cation exchange capacity was determined by frontal analysis chromatography (2) using hydrogen-ion saturated soil and barium acetate replacing solution. Pyrophosphate solubility was determined by thoroughly mixing samples of soil with a saturated solution of sodium pyrophosphate and comparing the color produced on filter paper strips with standard solutions[2] having a solubility of ¼ percent, ¾ percent and 2 percent. Electrophoretic mobility of brown-colored components present in 0.3M sodium pyrophosphate extracts of air-dried soil in 0.03M sodium pyrophosphate, pH 7.4, was determined in a Spinco Model R cell. The electrophoretograms were scanned with a Spinco Analytrol densitometer. Position of fluorescent bands was located under UV light. Differential thermal analysis was conducted on soil samples diluted (3:1) with calcined alumina. The samples were heated in air at a rate of 10°C per minute to 950°C. Calorific value (oxygen bomb method), sulfur content, and volatile components (heating in a covered platinum crucible over flame of constant heat output for 7 min.) were obtained for some samples[3].

Results and Discussion

Three layers of markedly different characteristics were visible in profiles A and B. The high water table in the virgin soil prevented examination of the complete profile. The plow layers of profiles A

[2]Supplied by J. E. Dawson, Cornell University.

[3]Analyses made by W. A. Mueller, Department of Metallurgical Engineering, The Ohio State University.

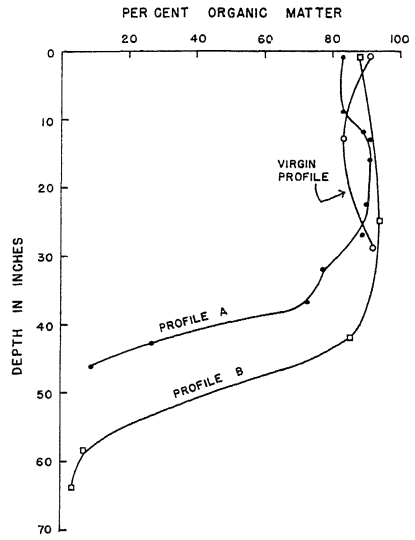

Fig. 1.—Distribution of organic matter in organic soil profiles.

and B were black in color, friable and had a crumb structure. The intermediate layers were bark brown, fibrous and stratified except at the bottom where the structure appeared to be that of disintegrated peat. The surfaces of cracks in these intermediate layers were coated with dark-colored material, apparently the result of aerobic oxidation and humification. The basal organic layers were dark gray to black in color, sticky and without classifiable structure. The blue-colored silty clay substratum was composed[4] of 0.4 percent very coarse sand, 5.6 percent very fine sand, 42.1 percent silt and 46.6 percent clay (17.7 percent very fine clay). DTA thermograms and infrared spectra indicated that the clay fraction contained considerable kaolinite. Free calcium carbonate was not detected. The profile of the virgin soil was somewhat different in that it contained a dark-colored layer at a depth of 12″-14″. This layer probably developed during an oxidative period but later became flooded and submerged with subsequent deposition of organic matter.

The distribution of organic matter in the three profiles is shown in figure 1. Gross differences were absent until the effect of depth of organic matter became apparent. Profile B was about 10 inches deeper than profile A. Not all of the difference in depth can be attributed to subsidence since bench mark measurements[5] have shown that this soil subsided at an average rate of 0.6 inch per year from 1948 to

[4]Analysis by Soil Survey Laboratory, Ohio Agricultural Experiment Station and The Ohio State University.

[5]Goins, T. Unpublished data, Ohio Agricultural Experiment Station

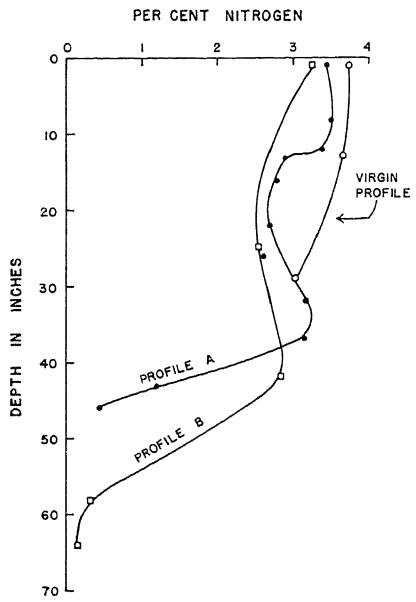

Fig. 2.—Distribution of nitrogen in organic soil profiles.

1956. Biological oxidation of the organic matter and heavy fertilizer applications may have resulted in a reduction in the percent organic matter in the plow layer of profile A.

The distribution of nitrogen in the cultivated profiles (figure 2) was similar to the distribution of organic matter, but nitrogen content appeared to be better correlated with pH (figure 3) than organic matter content. Reaction of the surface layer in the cultivated profiles was altered primarily by application and leaching of lime. Distinct differences in type of parent material in the profile were not observed, but the bog waters may have been more alkaline when the deeper layers of soil were being formed. Some leaching of calcium no doubt occurred prior to addition of lime, but the layer of highest pH was just below the tile. This alkaline layer was black in color and had a rather low pyrophosphate solubility (table 1). It may have been composed chiefly of gyttja or organic matter rich in nitrogen and calcium which had been leached from the upper layers of the profile. Samples of this dark colored basal horizon absorbed 70 percent of the water-soluble components extracted from samples of surface soil, while only 18 percent was absorbed by samples of the fibrous intermediate layer and 46 percent by the mineral substratum. Volatility (table 1) increased with depth suggesting that easily combustible low molecular weight components were leached out of the surface layer and absorbed in the

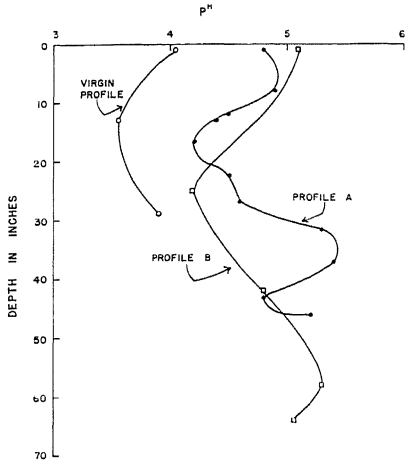

Fig. 3.—pH of organic soil profiles.

intermediate and basal layers. Sulphur content also increased with depth.

Striking differences in physico-chemical properties of the three major layers of profile A are shown in table 1 and figures 4 and 5. The high solubility in pyrophosphate, high cation exchange capacity and electrophoretic mobility of the dark-colored pyrophosphate soluble component in the surface layer (0-11″) suggests that this soil could be classified as muck. Considerable biological oxidation and humification in this surface layer has taken place since the soil was originally classified in 1942 (8).

There was a change in hue and a distinct change in physico-chemical properties of the soil in the intermediate layer. Pyrophosphate solubility of samples taken from the 21.5 inch to 28 inch depth was in the range for peat. The cation exchange capacity of 153 me/100g and the nature of the electrophoretic mobility of pyrophosphate soluble components (figure 4) indicate that the charge density and degree of humification in this layer was less than that of muck. A brown-colored component of negligible charge density was also present in soil from this layer. The intermediate layer can be classified as disintegrated peat.

Pyrophosphate solubility of the sample from the basal layer (30.5″ to 38″) was somewhat high, but the color, consistency and charge density of the pyrophosphate soluble components from this layer suggests that it could be classified as sedimentary peat. The relatively

TABLE 1.—Some Physical and Chemical Properties of Profile A.

Depth (Inches)	Munsell Color		Pyrophosphate Solubility (Percent)	Cation Exchange Capacity (me/100gm)	Calorific Value (Calories)	Volatile Matter (Percent)	Sulfur (Percent)	Carbon/ Nitrogen Ratio
	Natural	Air-Dried						
0-11	7.5 YR 2/0	7.5 YR 2/0	2	246	5500	69	0.73	14.0
21.5-28	7.5 YR 2/1	10 YR 2/2	1/4	153	5500	75	1.54	20.0
30.5-38	2.5 YR 2/0	7.5 YR 2/1	1/4	185	5550	87	2.10	14.1

TABLE 2.—Some Physical and Chemical Properties of Profile B and the Virgin Profile.

Depth (Inches)	Munsell Color		Pyrophosphate Solubility (Percent)	Carbon/Nitrogen Ratio
	Natural	Air-Dried		
		Profile B		
0-2	7.5 YR 2/0	5 YR 2/1	3/4	15.7
24-26	5 YR 2/1	5 YR 3/2 to 2/2	3/4	21.7
41-43	10 YR 2/1	5 YR 3/1 to 4/1	1/4	17.7
57.5-59	5 YR 3/0	5 YR 4/1	1/4	9.8
		Virgin Profile		
0-1	5 YR N/2 to 2/1	5 YR 2/1 to 3/1	2	14.0
12-14	5 YR 2/1	2.5 YR 3/4	2	13.5
28-30	5 YR 2/1	5 YR 2/2 to 3/2	3/4	18.2

high cation exchange capacity and presence of muck-like brown-colored polymers indicated that this layer contained considerable muck (perhaps gyttja). The electrophoretic pattern (figure 4) of the pyrophosphate soluble materials suggests the presence of polymers having a range in charge density.

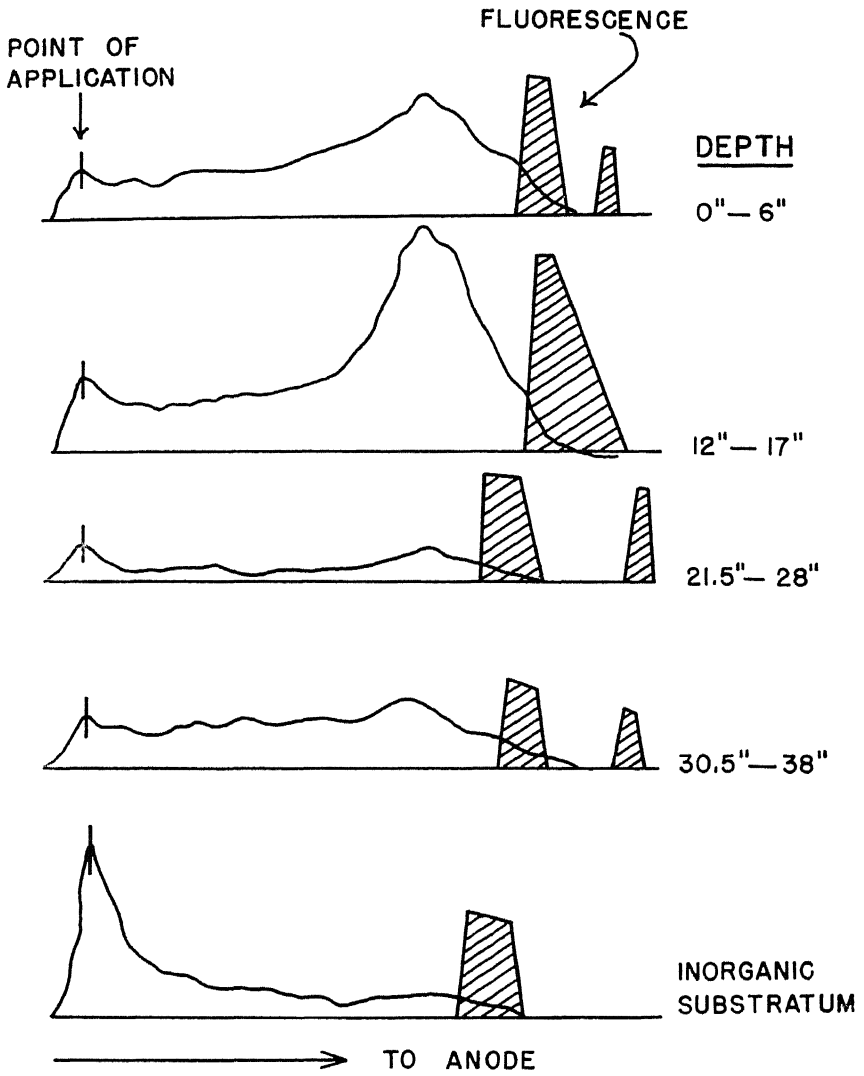

Fig. 4.—Electrophoretic pattern of fluorescent and brown-colored components in $Na_4P_2O_7$ extracts from horizons of profile A.

Fluorescent components were detected in pyrophosphate extracts from all layers. As noted by other investigators (4, 7), the fluorescent components were detected near the leading edge of the electrophoretically separated brown-colored component. Either the fluorescent component is highly charged and migrates rapidly during electrophoresis, or it is absorbed on a highly charged brown-colored polymer.

DTA thermograms of samples taken from several layers in profile A are shown in figure 5. The first exothermic peak near 275°C corresponded to a peak in holocellulose from Sphagmum-Eriophorum peat (5). The second peak near 500°C may have been due to burning of "fixed" carbon while the peak near 675°C may have been caused by the burning of elemental carbon (3). The exothermic peak from 500 to 700°C falls within the range of the second exothermic peak of coals. There was little difference in the thermograms of the samples from the 0-17.5″ and 30.5-38″ layers suggesting similarity in burning characteristics. Calorific values (table 1) were also similar. Intensity of the peaks in the thermogram of humic acid was different from the thermogram of the soil from the 0-17.5″ layer from which it was derived. Peaks near 300°C and 475°C were similar to those from humic acid prepared from Sphagnum-Eriophorum peat (5). The organic matter absorbed on the inorganic substratum gave the typical exothermic "masking effect" (250-500°C) for organic materials adsorbed on clay. The second major exothermic peak indicated that muck may have been adsorbed. This peak, and most of the peak in

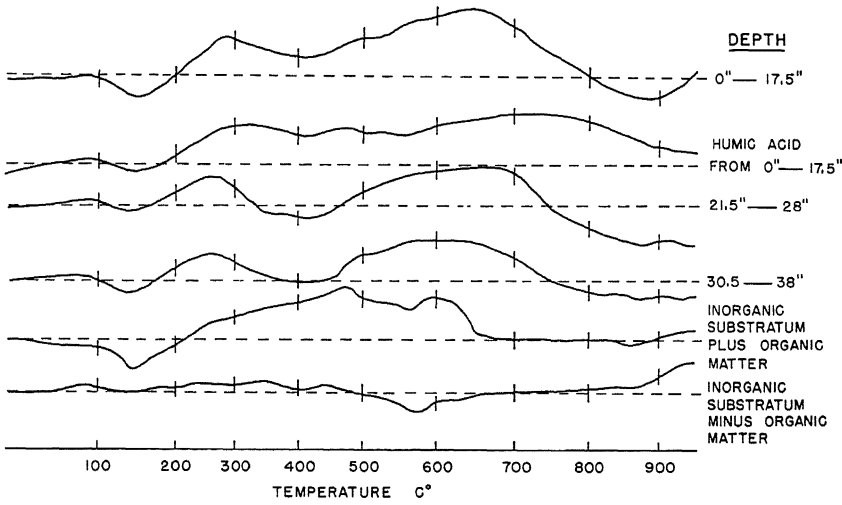

Fig. 5.—DTA curves of samples from profile A.

the region of the "masking effect" was removed by repeated treatment of the sample with hydrogen peroxide. The endothermic peak at 575°C indicates the presence of kaolinite.

Profile B and the virgin profile were not extensively studied, but table 2 shows that the surface soil was not as highly oxidized or humified as that of profile A. The 41-43" zone in profile B was part of the sedimentary, dark-colored inundated layer described above. The data again suggest a regressive profile development in the virgin soil. Data from the 28-30" zone is similar to that from the intermediate horizons in profiles A and B.

All of the profiles appeared to be highly humified and data from paper electrophoresis, DTA, organic matter content, calorific value and pyrophosphate solubility indicate that the soils should be classified as muck rather than peat. The absence of marl and an impermeable sedimentary peat strata suggests that the soil can be used for crop production until the organic matter is lost by subsidence. Subsequent utilization will depend upon the drainability of the organic substratum.

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